U.S. DEPARTMENT OF COMMERCE
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PB-261 086

A Summary of Hazardous Substance Classification Systems

Environmental Protection Agency, Washington, D C

1975

BIBLIOGRAPHIC DATA SHEET	1. Report No. EPA/530/SW-171	2.	3. Recipient's Accession No.
4. Title and Subtitle A summary of hazardous substance classification systems			5. Report Date Dec 1975 6.
7. Author(s) Allen M. Kohan			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Same as Box 12			10. Project/Task/Work Unit No. 11. Contract/Grant No.
12. Sponsoring Organization Name and Address U.S. Environmental ProtectionAgency Office of Solid Waste Management Programs			13. Type of Report & Period Covered 14.

15. Supplementary Notes
A current report on solid waste management

16. Abstracts

This paper describes the criteria used by 23 systems to define a "hazardous substance," primarily for regulatory purposes.

17. Key Words and Document Analysis. 17a. Descriptors

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 61
ia	20. Security Class (This Page UNCLASSIFIED	22. Price $4.50/3.00

FORM NTIS-35 (REV. 10-73) ENDORSED BY ANSI AND UNESCO. THIS FORM MAY BE REPRODUCED USCOMM-DC 8265-P74

EPA/530/SW-171
DECEMBER 1975

349082

PB 261 086

a summary of hazardous substance classification systems

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U. S. DEPARTMENT OF COMMERCE
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An environmental protection publication in the solid waste management series (SW-171). Mention of commercial products does not constitute endorsement by the U.S. Government. Editing and technical content of this report were the responsibilities of the Hazardous Waste Management Division of the Office of Solid Waste Management Programs.

Single copies of this publication are available from Solid Waste Information, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268.

A SUMMARY OF

HAZARDOUS SUBSTANCE CLASSIFICATION SYSTEMS

This report (SW-171) was written for the

Office of Solid Waste Management Programs

by Allen M. Kohan

U.S. ENVIRONMENTAL PROTECTION AGENCY

1975

Contents

PAGE

I. Introduction and Summary 1

II. Consumer Product Safety Commission 6

TITLE 16, (COMMERCIAL PRACTICES), CFR, PART 1500 6

III. Department of Transportation 10

TITLE 49, (TRANSPORTATION), CFR, PARTS 100-199 10
U.S. COAST GUARD 12
NATIONAL ACADEMY OF SCIENCES REPORT 13

IV. Department of Health, Education, and Welfare 17

FEDERAL FOOD, DRUG, AND COSMETIC ACT 17
NATIONAL INSTITUTE OF OCCUPATIONAL SAFETY AND Health (NIOSH) 18
Toxic Substances List 18
Priority list 21
NATIONAL CANCER INSTITUTE 23

V. Environmental Protection Agency 24

PESTICIDE PROGRAMS, (TITLE 40, CFR, PART 162) 24
OCEAN DUMPING, (TITLE 40, CFR, PART 227) 25
DRINKING WATER STANDARDS 27
FEDERAL WATER POLLUTION CONTROL ACT, AS AMENDED 30
Sec. 304(a)(1) - Water Quality Criteria 30
Sec. 307(a) - Toxic Pollutant List 33
Sec. 311(b)(2)(A) - Hazardous Substance Spills 34
CLEAN AIR ACT - SEC. 112 36
SEWAGE SLUDGE WORKING GROUP 37
TRW SYSTEMS GROUP REPORT 37
BATTELLE MEMORIAL INSTITUTE REPORT 42
BOOZ-ALLEN APPLIED RESEARCH, INC. REPORT 46

VI. Department of Defense 50

DEPARTMENT OF THE ARMY 50
DEPARTMENT OF THE NAVY 50

VI. State Regulations 52

CALIFORNIA STATE LIST 52

VII. References 53

IX. Appendix 54

INTRODUCTION AND SUMMARY

This paper describes the criteria used by 23 systems to define a "hazardous substance," primarily for regulatory purposes. The predominance of Federal systems is explained by the number of Federal statutes mandating regulation of hazardous substances in food, in transport, in the work place, and in the air and water environment. In addition, the supply component of the military services uses hazard ratings to help determine precautions needed for storage and shipment of materials. Only the State of California system has been developed for the purpose of comprehensively managing hazardous wastes, including their transport and disposal.

The set of criteria used by each of the hazardous substance classification systems is shown in Table A - Classification Criteria. The only systems not shown in this table are the NIOSH priority list, and the systems of the EPA Sewage Sludge Working Group and the U.S. Coast Guard. The priority list had no criteria that could be categorized, the working group is still drafting guidelines for heavy metal content in sewage sludge, and the Coast Guard regulations are essentially identical to Title 49, Code of Federal Regulations (CFR), Parts 100-199.

Every classification system studied uses toxicological criteria in determining whether a substance should be classified as hazardous. Many systems utilize the toxicology criterion as the primary screen for identifying hazardous substances, although their focus is on acute rather than chronic

TABLE A - CLASSIFICATION CRITERIA

System	Criteria: Toxicological	Flammability	Explosive	Corrosive	Reactivity	Oxidizing material	Radioactive	Irritant	Strong sensitizer	Bioconcentration	Carcinogenic, mutagenic, teratogenic	Sufficient quantity
Title 15, U.S. Code, Sec. 1261	X	X		X			X	X	X			X
CPSC-Title 16, CFR, Part 1500	X	X		X			X	X	X			X
Food, Drug, and Cosmetic Act	X									X	X	X
DOT-Title 49, CFR, Parts 100-199	X	X	X	X		X	X	X				X
Pesticides-Title 40, CFR, Part 162	X	X								X	X	
Ocean Dumping-Title 40, CFR, Part 227	X									X	X	X
NIOSH-Toxic Substances list	X										X	
Drinking Water Standards	X									X	X	
FWPCA Sec. 304 (a)(1)	X									X	X	
Sec. 307 (a)	X									X	X	X
Sec. 311 (b)(2)(A)	X											X
Clean Air Act-Sec. 112	X							X			X	
California State List	X	X	X	X				X	X			
National Academy of Sciences	X	X			X							
TRW Systems Group	X	X	X				X			X		X
Batelle Memorial Institute	X	X	X		X	X	X	X		X	X	
Booz-Allen Applied Research, Inc.	X	X	X		X							X
Dept. of the Army	X											
Dept. of the Navy	X	X	X	X	X	X	X					
National Cancer Institute	X									X	X	X

toxicity data. Acute toxicity data are more extensive than chronic toxicity data, and the results are more clear-cut (i.e., death versus some level of bodily impairment). The acute toxicity tests most frequently used in these systems are the lethal doses of a substance administered orally and dermally, and the lethal concentration of a substance administered by inhalation.

Other acute toxicity tests included the concentration of a substance lethal to aquatic life or causing a decrease in aquatic flora. One chronic toxicity criterion used in several systems was the Threshold Limit Value (TLV) of a substance, (see discussion of TRW Systems Group).

The acute toxicity levels and flammability criteria utilized by different systems for classifying substances as hazardous are depicted in Table B. The Federal Hazardous Substances Labeling Act, (Title 15, U.S. Code, Sec. 1261), provided the definition of "highly toxic" substances that was subsequently incorporated into many classification systems.

This Act's definitions of "flammable" and "extremely flammable" substances were also incorporated into other classification systems, although these criteria were not as widely adopted as the "highly toxic" criterion. (The "combustible" classification shown in Table B, did not appear in the original act.)

Other classification criteria are not as similar among systems as the toxicological or flammability criteria. The source of each system's classification criteria is noted, if available. The "sufficient quantity" criterion is

TABLE B - ACUTE TOXICITY AND FLAMMABILITY CRITERIA

SYSTEM	HIGHLY TOXIC SUBSTANCES† ORAL LD_{50} mg/kg	INHALATION LC_{50} (dust or mist) micrograms per liter	INHALATION LC_{50} (gas or vapor) ppm	DERMAL LD_{50} mg/kg	AQUATIC LIFE LC_{50} mg/l	AQUATIC FLORA TL_m ppm	FLAMMABILITY‡ EXTREMELY Flammable	HIGHLY FLAMMABLE	FLAMMABLE	COMBUSTIBLE
Title 15, USC., Sec. 1261	50	2,000	200	200			$F_p \leq 20°F$		$20°F \leq F_p \leq 80°F$	$80°F < F_p \leq 150°F$
CPSC-Title 16,CFR, Part 1500	50	2,000	200	200			$F_p \leq 20°F$		$20°F < F_p \leq 80°F$	$80°F < F_p \leq 150°F$
DOT Title 49, CFR, Parts 100-199	50	2,000	200	200					$F_p \leq 100°F$	$100°F < F_p \leq 200°F$
Pesticides-Title 40, - CFR, Part 162	50	2,000	200	200			$F_p \leq 20°F$*		$20°F < F_p \leq 80°F$*	
NIOSH-Toxic Substances List	5,000**	2,000**		2,800**						
FWPCA-Sec. 307(a)***	50	2,000	200	200	10					
Sec. 311(b)(2)(A)	50	2,000	200	200	500	100				
California State List	50	2,000	200	200			$F_p \leq 20°F$		$20°F < F_p \leq 80°F$	
National Academy of Sciences	5 to 50		50 to 200	20 to 200	1		$F_p \leq 100°F$ $B_p \leq 100°F$	$F_p \leq 100°F$ $B_p > 100°F$		
Battelle Memorial Institute	50	2,000	200	200	1,000	1,000	$F_p < 73°F$ $B_p \leq 100°F$			
Booz-Allen Applied Research, Inc.	50	5,000(man) 2,000(ecology)			100		$F_p < 100°F$ $B_p < 100°F$			

†Oral LD_{50}, Inhalation LC_{50}, Dermal LD_{50} are defined in Federal Hazardous Substances Labeling Act section; aquatic life LC_{50} and aquatic flora TL_m are defined in sections dealing with Sec. 307(a) and Sec. 311(b)(2)(A) of FWPCA, respectively. Unless otherwise indicated, substances having toxicities less than or equal to the amount indicated are classified as highly toxic

‡F_p: flash point; B_p: boiling point

*Proposed standard

**LCLo, LC_{50}, LDLo, or LD_{50}: no time limit for tests given, see NIOSH section.

***Currently under revision.

often an exemption for very small amounts or packages of a substance, i.e., too small for a label. Such exemptions are included in Title 15, U.S. Code, Sec. 1261, and CPSC and DOT regulations. In other cases, the quantity of a substance produced or discharged is a criterion considered when classifying substances (e.g., TRW Systems Group and Booz-Allen Applied Research, Inc.), or designating a substance as hazardous for purposes of regulation (e.g., Sec. 307 (a) and Sec. 311 (b) (2) (A) of the FWPCA).

CONSUMER PRODUCT SAFETY COMMISSION

Title 16, (Commercial Practices), CFR, Part 1500

Section 30 (a) of the Consumer Product Safety Act (P.L. 92-573) vests authority granted under the Federal Hazardous Substances Labeling Act (P.L. 86-613, enacted July 12, 1960) in the Consumer Product Safety Commission. The Commission is therefore responsible for enforcement of labeling requirements governing hazardous substances intended or packaged in a form suitable for use in the household. (Exemptions to such requirements are allowed for food, drugs, cosmetics, fuels, small packages, minor hazards, and special circumstances.)

The Federal Hazardous Substances Labeling Act (referred to as "the Act") defines a "hazardous substance" as:

> any substance or mixture of substances which (i) is toxic, (ii) is corrosive, (iii) is an irritant, (iv) is a strong sensitizer, (v) is flammable, or (vi) generates pressure through decomposition, heat, or other means, if such substance or mixture of substances may cause substantial personal injury or substantial illness during or as proximate result of any customary or reasonably foreseeable ingestion by children.

The term "toxic" is applied to any substance (other than a radioactive substance) which has the capacity to produce personal injury or illness to man through ingestion, inhalation, or absorption through any body surface.

The term "highly toxic" is defined as:

> any substance which falls within any of the following categories: (a) Produces death within fourteen days in half or more than half of a group of ten or more laboratory white rats each weighing between two hundred and three hundred grams, at a single dose of fifty milligrams or less per kilogram of body weight when orally administered, (oral LD_{50}); or (b) produces death within fourteen days in half or more than half or a group of ten or more laboratory white rats each weighing between two hundred grams, when inhaled continuously for a period of one hour or less at an atmospheric concentration of two hundred parts per million, (ppm), by volume or less of gas or vapor or two milligrams per liter by volume or less of mist or dust, provided such concentration is likely to be encountered by man when the substance is used in any reasonably foreseeable manner, (inhalation LC_{50}); or (c) produces death within fourteen days in half or more than half of a group of ten or more rabbits tested in a dosage of two hundred milligrams or less per kilogram of body weight, when administered by continuous contact with the bare skin for twenty-four hours or less, (dermal LD_{50}).

The term "corrosive" means any substance which in contact with living tissue will cause destruction of tissue by chemical action; such term shall not refer to action on inanimate surfaces. The term "irritant" means any substance not corrosive which in immediate, prolonged, or repeated contact with normal living tissue will induce a local inflammatory reaction.

The term "strong sensitizer" means:

> a substance which will cause on normal living tissue through an allergic or photodynamic process a hypersensitivity which becomes evident on reapplication of the same substance, and which is designated as such by the Commission. Before designating any substance as a strong sensitizer, the Commission upon consideration of the frequency of occurrence and severity of the reaction, shall find that the substance has a significant potential for causing hypersensitivity.

The term "extremely flammable" shall apply to any substance which has a flash point at or below 20 F as determined by the Tagliabue Open Cup Tester, and the term "flammable" shall apply to any substance which has a flash point above 20 F, to and including 80 F, as determined by the same test.

These hazardous substance definitions are incorporated into Sec. 1261 of Title 15 (Commerce and Trade) of the U.S. Code. The only difference noted between the hazardous substance definitions found in the code and in the Act was the inclusion in the former of a "combustible" category for those substances with flash points greater than 80 F, but less than or equal to 150 F.

Title 16 (Commercial Practices), CFR, Part 1500.3 contains the following items which interpret, supplement, or provide alternatives to the aforementioned hazardous substance definitions, (which are also contained in this Part):

"Toxic substances" are defined as those substances falling within any of the following categories:

(1) Any substance having an oral LD50 of more than 50 mg/kg but not more than 5 g/kg of body weight. Substances falling in the toxicity range between 500 mg and 5 grams per kilogram or body weight will be considered for exemption from some or all of the labeling requirements;

(2) Any substance having an inhalation LC_{50} of more than 200 ppm but not more than 20,000 ppm by volume of gas or a vapor or more than 2 mg but not more than 200 mg per liter by volume of mist or dust; or

(3) Any substance having a dermal LD_{50} of more than 200 mg/kg of body weight but not more than 2 g/kg of body weight.

"Irritants" are subdivided into "primary irritants to the skin" and eye irritants. Primary irritants are substances that are not corrosive and result in an empirical score of five or more when tested by the method described in Sec. 1500.41. Eye irritants are defined as those substances giving a positive test result when the test method described in Sec. 1500.42 is used.

"Extremely flammable solid" means a solid substance that ignites and burns at an ambient temperature of 80 F or less when subjected to friction, percussion or electrical spark. "Flammable solid" means a solid substance that when tested by the method described in Sec. 1500.44, ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.

A susbtance is considered "corrosive" to the skin, if when tested by the technique described in Sec. 1500.41, the structure of the tissue at the site of contact is destroyed or changed irreversibly in 24 hours or less. Criteria for determining whether a substance is hazardous because it generates pressure through decomposition, heat, or other means are also listed.

DEPARTMENT OF TRANSPORTATION

Title 49, (Transportation), CFR, Parts 100-199

Title 49, CFR, Parts 100-199 contain regulations covering the preparation of hazardous materials, (including their loading and storage), for transportation by common carriers, rail freight, rail express, rail baggage, highway or water. These regulations also cover construction containers, packaging, weight, marking, labeling, billing, and shipper's certificate of compliance. (Sec. 171.1(a)).

Section 173.2 lists the priority of hazards in the following order (from highest to lowest priority):

(1) Radioactive material
(2) Flammable or nonflammable gas
(3) Extremely toxic liquid or solid
(4) Flammable liquid
(5) Oxidizing material
(6) Flammable Solid
(7) Corrosive material, (liquid)
(8) Highly toxic liquid or solid
(9) Irritating material
(10) Corrosive material, (solid)
(11) Combustible liquid

Sec. 173.326 lists thirteen poisonous gases that qualify as extremely dangerous poisons. The definition for less dangerous, liquid or solid poisons is contained in Sec. 173.343. The oral, inhalation, and dermal toxicities of a substance are used as criteria in determining this class of poisons. The toxicity levels chosen were identical to the "highly toxic" category of Title 15, U.S. Code, Sec. 1261.

Flammable and combustible liquids are defined in Sec. 173.115. Flammable liquids are those liquids having a flash point below 100 F. Combustible liquids are those liquids having a flash point above 100 F and below 200 F. Flammable compressed gases are defined in Sec. 173.300 (b).

Explosives forbidden from transportation by common carriers by rail freight, rail express or highway, or water are defined in Sec. 173.51. Sec, 173.52 categorizes explosives acceptable for transportation into three classes: (1) Class A explosives; detonating or otherwise of maximum hazard, (defined in Sec. 173.53); (2) Class B explosives; flammable hazard, (defined in Sec. 173.88); and (3) Class C explosives, minimum hazard (defined in Sec. 173.100).

Oxidizing materials are defined (Sec. 173.151) as those substances that yield oxygen readily, thereby stimulating the combustion of organic matter. Corrosives are defined as in Title 21 (Food and Drugs), CFR, Sec. 191.1 and tested by the method described in Sec. 191.11. A liquid is considered to have

a severe corrosion rate if its corrosion rate exceeds 0.250 inches per year on steel (SAE 1020) or aluminum (nonclad 1075-T6) at a test temperature of 130 F, (Sec. 173.240 of Title 49). An acceptable test is described in NACE Standard TM-01-69.

Irritants, (defined in Sec. 173.381) are defined as those liquid or solid substances which upon contact with fire or when exposed to air give off dangerous or intensely irritating fumes, but not including any Class A, extremely poisonous materials.

An "etiologic agent" (defined in Sec. 173.386) means a microorganism, or its toxin which causes or may cause human disease and is limited to those agents listed in Title 42 (Public Health), CFR, Sec. 72.25(c). Radioactive materials are defined by fissile class and transport group in Sec. 173.389.

U.S. Coast Guard

Chapter I of Title 46 (Shipping), CFR, contains U.S. Coast Guard regulations governing shipment of materials. Most of the hazardous materials regulations are similar to those described in Title 49, Parts 100-199. One difference, however, is that Sec. 146.27-1 describes a hazardous article, (other than an explosive, inflammable liquid or solid, oxidizing material, corrosive liquid, compressed gas, poisonous article or combustible liquid) as one which:

(a) Is liable to spontaneous heating in excess of 10 F when subjected to a test of three continuous hours in a Mackey apparatus at or below a temperature of 212 F; or

(b) Liberates vapor susceptible to ignition by spark or open flame at or below a temperature of 300 F.

National Academy of Sciences[1] Systems for Evaluation of the Hazards of Bulk Water Transportation of Industrial Chemicals

This study classifies the hazards of bulk water transportation of industrial chemicals in each of nine categories (see Table C - Summary of Hazard Evaluation Criteria).[1] The hazard rating of an industrial chemical is evaluated independently for each category. No ranking of chemical hazard by combining the category ratings into one overall figure can be justified, however.

The fire hazard rating, Category 1, classifies those chemicals with a flash point of less than 100 F and a boiling point of less than 100 F as "extremely hazardous," while those chemicals with a flash point less than 100 F and a boiling point greater than 100 F are classified as "highly hazardous."

Categories II thru V are occupational health hazard ratings. The hazard of liquid contact with skin and eyes is classified in Category II. Those chemicals having a dermal LD_{50} of less than 20 mg/kg are classified as "extremely hazardous," while those chemicals with a LD_{50} of greater than 20 mg/kg, but not more than 200 mg/kg, are classified as "highly hazardous."

GRADE	I	II	III	IV	V	VI	VII	VIII	XI
	FIRE	HEALTH				WATER POLLUTION		REACTION	
		Skin and Eyes	Vapor Inhalation	Gas Inhalation	Repeated Inhalation	Human Toxicity	Aquatic Toxicity	Water Reaction	Self-Reaction
0	Insignif. Hazard Non-combust	Insignif. Hazard All not described below	Insignif. Hazard All not described below	Not Applicable	Insignif. Hazard OSHA ≥ 1000 ppm	Insignif. Hazard LD_{50} > 5000 mg/kg	Insignif. Hazard TL_m >1000mg/l	Insignif. Hazard	Insignif. Hazard No appreciable self-reaction
1	Slightly Hazardous FPcc >140°F (60°C)	Slightly Hazardous Corrosive to eyes-	Slightly Hazardous Depressants, Asphyxiants	All those not described below	Slightly Hazardous OSHA 100-1000 ppm	Slightly Hazardous LD_{50} 500-5000mg/kg	Practically Nontoxic TL_m 100-1000 mg/l	Slightly Hazardous e.g. Cl_2	Slightly Hazardous May polymerize with low heat evolution
2	Hazardous FPcc 100°F-140°F (37.8°-60°C)	Moderately Hazardous Corrosive to skin	Moderately Hazardous LC_{50} 200-2000 ppm	Moderately Hazardous LC_{50} 200-2000ppm	Moderately Hazardous OSHA 10-100 ppm	Moderately Hazardous LD_{50} 50-500/mg/kg	Slightly Toxic TL_m 10-100 mg/l	Hazardous e.g. NH_3	Hazardous Contamination may cause polymerization, no inhibitor required
3	Highly Hazardous (37.8°C) FPcc <100°F BP >100°F (37.8°C)	Highly Hazardous LD_{50} 20-200mg/kg 24 hr. skin contact	Highly Hazardous LC_{50} 50-200ppm or 0.5-2 mg/l	Highly Hazardous LC_{50} 50-200 ppm	Highly Hazardous OSHA 1-10 ppm	Highly Hazardous LD_{50} 5-50 mg/kg	Moderately Toxic TL_m 1-10 mg/l	Highly Hazardous e.g. Oleum	Highly Hazardous May polymerize, requires stabilizer
4	Extremely Hazardous (37.8°C) FPcc < 100°F BP < 100°F (37.8°C)	Extremely Hazardous LD_{50} ≤ 20mg 24 hr. skin contact	Extremely Hazardous LC_{50} ≤ 50ppm or ≤ 0.5 mg/l	Extremely Hazardous LC_{50} ≤ 50ppm	Extremely Hazardous OSHA < 1ppm	Extremely Hazardous LD_{50} < 5 mg/kg	Highly Toxic TL_m < 1 mg/l	Extremely Hazardous e.g. SO_3	Extremely Hazardous Self-reaction may cause explosion or detonation

Table C - SUMMARY OF HAZARD EVALUATION CRITERIA

The hazard rating for the short-term inhalation of gas or vapor, Categories III and IV, classifies those chemicals with an inhalation LC_{50} of less than 50 ppm or less than 0.5 mg/l as "extremely hazardous," while those chemicals with a LC_{50} of greater than 0.5 mg/l, but not more than 2 mg/l, are classified as "highly hazardous."

The hazard rating for repeated inhalation of gases and vapors, Category V, is based on Title 29 (Labor), CFR, Sec. 1910.93. Those substances listed in specified tables or regulated elsewhere in this section, having an 8-hour time weighted average exposure limit of less than 1 ppm are classified as "extremely hazardous," while those substances having an exposure limit of more than 1 ppm but not more than 10 ppm are classified as "highly hazardous."

Water pollution hazard ratings, Categories VI, and VII, are concerned with the toxicological dangers, to humans and to aquatic life, associated with a chemical spilled or dumped into waterways. Those chemicals with an oral LD_{50} of less than 5 mg/kg are classified as "extremely hazardous," while those chemicals with oral LD_{50} of more than 5 mg/kg, but not more than 50 mg/kg, are classified as "highly hazardous." Substances having a 96-hour aquatic life LC_{50} (or median threshold limit, TLm) of less than 1 mg/l are classified as "highly toxic." These ratings do not address the problem of bioaccumulation.

Reactivity hazard ratings, Categories VIII and IX, are concerned with the likelihood of chemical reaction with water, or chemical self-reaction, usually via polymerization. The "extremely hazardous" water reaction hazard rating is classified as a violent reaction of a chemical with an equal weight of water in a tank at ambient temperature. The "highly hazardous" rating is assigned to those chemicals that undergo a vigorous reaction with water under similar conditions. Chemicals that can undergo self-oxidation, and/or polymerization, possibly causing explosions or detonations, are classified as "extremely hazardous." Chemicals that may undergo self-reaction, and require special handling, such as incorporation of a stabilizer or polymerization inhibitor, are classified as "highly hazardous."

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Federal Food, Drug, and Cosmetic Act

The Federal Food, Drug, and Cosmetic Act mandates that any poisonous or deleterious substance added to any food shall be deemed to be unsafe in any quantity exceeding the limits fixed by the Secretary (of Health, Education, and Welfare) as necessary for the protection of public health (Sec. 406). Furthermore, under Sec. 408, those poisonous or deleterious pesticide chemicals not generally recognized as safe for use shall not exceed tolerance levels established by the Secretary with respect to use in or on raw agricultural commodities.

Tolerance levels for poisonous or deleterious substances are established on the basis of the best evidence currently available. Determination of a "safe" no-effect level in food is made considering toxicological studies, evidence of bioaccumulative properties, likelihood of body retention of the substance, amount of food likely to be consumed, and any other relevant factors.

Sec. 409 (c)(3)(A) stipulates that no food additive shall be deemed to be safe if it is found to induce cancer when ingested by man or animal. Thus, there are no "safe" no-effect levels for carcinogens. This provision does not apply with respect to the use of a substance as an ingredient of

feed for animals which are raised for food production if the Secretary of Health, Education, and Welfare finds that under specified conditions of use and feeding the additive will not adversely affect the animals for which the food is intended and that no residue of the additive will be found in any edible portion of such animal after slaughter or in any food yielded by or derived from the living animal.

National Institute of Occupational Safety and Health

Toxic Substances List. The National Institute of Occupational Safety and Health (NIOSH) in compliance with Sec. 20(a)(6) of the Occupational Safety and Health Act of 1970, (P.L. 91-596), periodically publishes a toxic substances list. Dosages differentiating relatively toxic and nontoxic substances according to route of administration to experimental animals are listed in Table D[2] . The limiting dosages were chosen on the basis of available data and toxicological judgment[3] .

The oral route of administration is the preferred testing method. This method is the most widely used and documented. The inhalation and skin absorption routes of administration are used in that order when data for oral administration are not available[2] .

The order of preferrence of test data by species is:

(1) Man	(6) Cat
(2) Rat	(7) Rabbit
(3) Mouse	(8) Pig

TABLE D

LIMITING DOSAGES DIFFERENTIATING RELATIVELY TOXIC AND NONTOXIC SUBSTANCES ACCORDING TO ROUTE OF ADMINISTRATION TO EXPERIMENTAL ANIMALS OF A MAXIMUM TOTAL (ACUTE)* DOSE CAUSING DEATH**

SPECIES (with abbreviations)	ROUTES OF ADMINISTRATION (with abbreviations)								
	Oral (orl) Rectal (rec) Intraduodenum (idu) Intracervix (icv)	Inhalation (ihl) 24-Hour Maximum		Skin (skn)	Parenteral				Unreported (unk)
					Intraperitoneal (ipr) Intrapleural (ipl)	Subcutaneous (scu) Intradermal (idr) Implant (imp)	Intravenous (ivn) Intramuscular (ims) Ocular (ocu) Intracerebral (ice) Intratracheal (itr) Intraplacental (ipc) Intravaginal (ivg) Intrarenal (irn)	Other (par)	
	mg/kg	ppm	mg/m³	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Hamster (ham), Frog (frg), Gerbil (grb)	2,500	5,000 (0.5%)	1,000	1,400	1,000	5,000	750	1,000	2,500
Rat (rat), Mouse (mus), Mammal, unspecified (mam)	5,000***	10,000 (1%)	2,000	2,800	2,000	10,000***	1,500	2,000	5,000
Rabbit (rbt), Guinea Pig (gpg), Chicken (ckn), Pigeon (pgn), Quail, (qal), Duck (dck), Turkey (trk), Bird (brd)	10,000	20,000 (2%)	4,000	2,800***	4,000	20,000	3,000	4,000	10,000
Dog (dog), Monkey (mky), Cat (cat), Pig (pig), Cattle (ctl), Domestic Animals: sheep, goat, horse (dom)	10,000	20,000 (2%)	4,000	5,600	4,000	20,000	3,000	4,000	10,000

*Applies to those substances for which acute or short term toxicity characterizes the response, e.g., fast-acting substances, irritants, narcoses-producing substances and most drugs. Does not apply to substances whose characteristic response results from prolonged exposures, e.g., silica, lead, benzene, carbon disulfide, carcinogens. Concentrations more appropriately characterizing the toxicity of long- or slow-acting substances are derived from non-acute toxicity studies.

**Calculated from experimental data (Stokinger).

***From Hine and Jacobson, AIHAAP 15, 141, 54.

(4) Dog (9) Guinea pig

(5) Monkey (10) Hamster

The limiting dosages shown in Table D for substances administered by any route other than inhalation may be:

(1) LCLo: Lethal Dose Low - the lowest dose of a substance (other than LD_{50}) introduced over any given period of time, and reported to have caused death in man, or the lowest single dose introduced in one or more divided portions and reported to have caused death in animals; or

(2) LD_{50}: Lethal Dose Fifty - the dose of a substance expected to cause death of 50% of an entire population of an experimental animal species, as determined from the exposure to the substance of a significant number from that population. Other lethal dosages (LD_{10}, LD_{30}), are used in absence of an LD_{50}, if available.

Limiting dosages for substance administered by inhalation may be:

(1) LCLo: Lethal Concentration Low - the lowest concentration of a substance, other than an LC_{50} in air, which has been reported to have caused death in animals when they have been exposed for 24 hours or less; or

(2) LC_{50}: Lethal Concentration Fifty - the concentration of a substance, in air, exposure to which for 24 hours or less would cause the death of 50% of an entire population of an experimental animal species, as determined from exposure to the substance of a significant number from that population.

In addition to toxic substances reported to have caused death in experimental animals, the toxic substances list includes those substances reported to have produced any toxic effect in man. There is no qualifying limitation to the duration of exposure, nor to the quantity or concentration of the substance, nor to the circumstances that resulted in the exposure. Also, the

list includes those substances reported to have produced any carcinogenic, teratogenic, mutagenic, or neoplastigenic effects in humans or animals. Qualifying toxic effects for animal data include the production of tumors (neoplastigenesis), whether benign or malignant (carcinogenesis), and the production of changes in the offspring, whether transmissible (mutagenesis) or not (teratogenesis). The reported effects may have been generated by exposure to the substance over any period of time and in any quantity or concentration of dose.

Priority List. NIOSH prepared another list, known as the priority list, for the purpose of ranking substances that would subsequently have occupational standards developed and recommended to the Occupational Safety and Health Administration (OSHA). The ranking of substances on the priority list was done by calculation of an overall rating. The overall rating was derived by multiplying the number of workers exposed to a substance by a severity rating. The severity rating was developed by a Delphi technique in which a list of compounds was sent out to some 50 industrial hygienists who rated the substances using a scale for relative severity[4]. Criteria documents were then developed for substances ranked highest on the priority list.

Criteria documents present background information on chemical exposure and morbidity. Evidence of the substance acting as a carcinogen, teratogen or mutagen, or inducing respiratory, cardiac, or nerve disease in humans or

animals is used in developing the recommended standard. Though usually there is extensive data on chemical exposure and morbidity, in most cases few good correlations between exposure and morbidity can be inferred. (See Appendix for listing of NIOSH recommended standards developed to data, and those planned for development through fiscal year 1976.)

OSHA is responsible for the promulgation of occupational safety and health standards. To data, criteria document development by NIOSH has resulted in the promulgation of standards for only two substances -- vinyl chloride and asbestos. Many chemical substances, however, are currently listed in Tables G-1, G-2, or G-3 of Sec. 1910.93 of Title 29 (Labor), CFR, and subject to regulations described therein. Also, 14 substances are designated as carcinogens and subject to regulations found in Sec. 1910.93c.

An employee's exposure to any material in Tables G-1 or G-3, the name of which is not preceded by "C", cannot exceed the 8-hour time weighted average, the acceptable ceiling concentration, or the acceptable maximum peak above the ceiling concentration for the given material. The acceptable maximum peak concentration may never be exceeded, and exposure to concentrations greater than the acceptable ceiling concentration cannot exceed the "maximum duration" time period listed in the table. The source of standards found in this table is the American National Standards Institute, 237 series.

Occupational health standards promulgated by OSHA for a given substance supercede those restrictions found in the previously referenced tables.

National Cancer Institute

The National Cancer Institute (NCI) is sponsoring a program to collect, analyze, and systematize information in the chemical description, production, distribution, and human exposure to carcinogenic chemicals which the public may come into contact with in significant amounts[4]. The program is designated "A Research Program to Acquire and Analyze Information on Chemicals that Impact on Man and His Environment." Criteria used by NCI's Chemical Selection Committee for selecting chemicals for carcinogenic testing are:

1. The degree of overall exposure
2. Projected new or increased human exposure
3. Exposure of subpopulations important to society
4. Epidemiological clues (high cancer incidence subpopulations)
5. Relation to known carcinogens
6. Gaps in knowledge

Collected data include such information as the quantity of chemicals available for exposure, and the routes of exposure, i.e., oral, dermal, respiratory, and peritoneal.

ENVIRONMENTAL PROTECTION AGENCY

Office of Pesticide Programs

Title 40 (Protection of Environment), CFR, Part 162 contains regulations for the enforcement of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended. Sec. 162.8 lists the criteria for economic poisons "highly toxic" to man. The oral, dermal, and inhalation toxicity levels used to classify "highly toxic" poisons are identical to those listed in Table 15, U.S. Code, 1261. The classification of economic poisons is done for labeling purposes.

Proposed rulemaking to revise current procedures for the registration of pesticides and establish procedures for the registration and classification of pesticides to conform with the provisions of FIFRA, as amended, was published in the Federal Register of October 16, 1974. Proposed Sec. 162.10 describes labeling requirements. Four toxicity categories are listed, with Category I corresponding to the "highly toxic" classification under the current definition of economic poisons. In addition to prescribed oral, inhalation, and dermal toxicity levels, Toxicity Category I includes eye effects and skin irritation criteria. If a substance causes irreversible corneal capacity at seven days or severe skin irritation or damage at 72 hours, then it would be classified under Toxicity Category I.

The proposed rulemaking includes flammability labeling requirements. "Extremely flammable" and "flammable" categories correspond to those found in Title 15, U.S. Code, Sec. 1261. Also, a "Caution" label is required for

non-pressurized containers having a flash point above 80 F and not over 150 F.

Acting under authority of Sec. 3(c)(5) of FIFRA, as amended, the Administrator proposes indices of presumptive refusal to register pesticides (Sec. 162.11). These indices include both acute and chronic toxicity criteria. "Use" classification criteria for newly and previously registered pesticide products are proposed (also in Sec. 162.11) under authority of Sec. 3(d) of FIFRA, as amended. Criteria for domestic, nondomestic, and outdoor applications of pesticides are delineated. Classification criteria for new pesticide registrations are generally less stringent than those for previously registered products.

Ocean Dumping

Sec. 102(a) of the Marine Protection, Research, and Sanctuaries Act of 1972 (P. L. 92-532) authorizes the Administrator to establish criteria for evaluating ocean dumping permit applications. Title 40, CFR, Part 227 is concerned with criteria for the evaluation of permit applications. Sec. 227.22(f) specifies that wastes with trace contaminants may be dumped under special permit when the following limits are not exceeded:

(1) Mercury and its compounds are not present in any solid phase of a waste in concentrations greater than .75 mg/kg, and the total concentration of mercury in the liquid phase of a waste does not exceed 1.5 mg/kg;

(2) Cadmium and its compounds are not present in any solid phase of a waste in concentrations greater than .6 mg/kg, and the total concentration of cadmium in the liquid phase of a waste does not exceed 3.0 mg/kg;

(3) The total concentrations of organohalogens do not exceed the limiting permissible concentrations of pollutants as defined in Sec. 227.71;

(4) The total amounts of oil and greases do not produce a visible surface sheen in an undisturbed water sample when added at a rate of one part waste material to 100 parts of water.

Sec. 227.71 defines limiting permissible concentration as:

(a) that concentration of waste material or chemical constituent in the receiving water which, after reasonable allowance for initial mixing in the mixing zone will not exceed .01 of a concentration shown to be toxic to appropriate sensitive marine organisms in a bioassay carried out in accordance with approved EPA procedures; or

(b) .01 of a concentration of a waste material or chemical constitutent otherwise shown to be detrimental to the marine envrionment.

The 96-hour median threshold value for aquatic life of a waste material or chemical constituent is used in computation of the limiting permissbile concentrations. Subsquent sections define the release and mixing zones.

The level of trace contaminants allowed in waste dumped under special permit and the definition of limiting permissible concentrations were derived from a working group's consensus judgment.

Drinking Water Standards

The current drinking water standards were promulgated by the U.S. Public Health Service in 1962. Proposed interim primary drinking water standards were published in the Federal Register on March 14, 1975, pursuant to Sec. 1412(a) of the Safe Drinking Water Act (P.L. 93-523). These standards will take effect 18 months after the date of promulgation. The current and proposed drinking water standards for inorganic and organic chemicals, and the proposed drinking water standards for pesticides are listed in Table E. (Note: Interim standards for aldrin, dieldrin, and DDT will be proposed pending the completion of a survey of selected water supplies. The survey is intended to estimate the current level of pesticides in U.S. drinking water supplies.) These standards are only concerned with those chemical substances regulated for health reasons. Other drinking water standards are concerned with such aesthetic qualities as odor, foaming and taste.

The rationale used in writing the current drinking water standards was that substances which may have deleterious physiological effects, or for which physiological effects were not known, should not be introduced into the water supply system in a manner which would permit them to reach the consumer. The total lifetime environmental exposure of man to a specific toxicant was considered when arriving at specific limits for the proposed interim primary drinking water standards. Choice of the concentration of a given substance permitted in drinking water was made after allowance for the amount of toxicant contributed by food (FDA guidelines for maximum allowable concentra-

TABLE E

DRINKING WATER STANDARDS

	Current (mg/l)	Proposed Interim Primary (mg/l)
Arsenic	0.05	0.05
Barium	1.0	1.0
Cadmium	0.01	0.01
Chromium (Cr^{+6})	0.05	0.05
Cyanide	0.2	0.2
Fluoride		
Daily air temperatures (°F)		
50.0 - 53.7	1.7	2.4
53.8 - 58.3	1.5	2.2
58.4 - 63.8	1.3	2.0
63.9 - 70.6	1.2	1.8
70.7 - 79.2	1.0	1.6
79.3 - 90.5	0.8	1.4
Lead	0.05	0.05
Mercury	none	0.002
Nitrate	45. (undesirable)	10.
Organics - Carbon Absorbable	0.2	0.7
Selenium	0.01	0.01
Silver	0.05	0.05

TABLE E (continued)

DRINKING WATER STANDARDS

Pesticides	Proposed Interim Primary (mg/l)
(i) Chlorinated Hydrocarbons	
Chlordane	0.003
Endrin	0.0002
Heptachlor	0.0001
Heptachlor Epoxide	0.0001
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
(ii) Chlorophenoxys	
2.4-D	0.1
2,4,5-TP Silvex	0.01

tions), or other environmental factors (such as the amount of lead asbestos through inhalation by people living in urban areas).

In formulating the proposed interim primary drinking water standards, consideration was given to the toxicities of a given substance and the likelihood of bioaccumulation, carcinogenicity, mutagenicity, or teratogenicity of that substance. Studies investigating the characteristics of a substance offered evidence that was often unclear, and sometimes conflicting, thus making the choice of a "safe no-effect" level in drinking water quite difficult. A safety factor, varying with the reliability of the evidence, was therefore used in derivation of the interim primary drinking water standards. The level of control chosen minimized the amount of a toxicant contributed by water, and this level was generally attainable by good quality control.

Federal Water Pollution Control Act, as Amended (FWPCA)

Sec. 304 (a)(1) -- Water Quality Criteria. The Administrator is obligated by this section to publish criteria for water quality taking into account identifiable effects on the propagation of fish and wildlife, recreational activities, public water supplies, and agricultural, industrial and other activities. Inorganic and organic chemicals for which water quality criteria have been written for health reasons appear in Table F.

Considerations similar to those mentioned for formulation of the proposed interim primary drinking water standards were used in derivation of

TABLE F - WATER QUALITY CRITERIA

Substance	Domestic Water Supplies (mg/l)	Freshwater Aquatic Life (mg/l)	Marine Aquatic Life (mg/l)	Other (mg/l)
Arsenic	0.05	none	none	0.1 - irrigation of crops
Barium	1.0	none	none	none
Beryllium*	none	0.011 - soft freshwater 1.1 - hard freshwater	none	0.1 - continuous use on all soils 0.5 - short-term irrigation on neutral to fine-textured soils
Cadmium*	0.01	soft water: 0.0004 hard water: 0.003 - for cladocerans and salmonid fishes 0.004 0.012 - for other, less sensitive, aquatic life	0.005	none
Chlorine	none	0.003 - salmonid fish 0.01 - other freshwater organisms	0.01	none
Chromium	0.05	0.3	none	none
Copper	(aesthetic)	+	+	none
Cyanide	0.2	0.005	0.005	0.005 - wildlife
Iron	(aesthetic)	1.0	none	none
Lead	0.05	**	none	none
Manganese	(aesthetic)	none	0.1 - for protection of consumers of marine molluska	none
Mercury	0.002	0.00005	0.0001	0.00005 - wildlife
Nitrate	10.0	none	none	none
Phthalate ester	none	0.003	none	none
Polychlorinated biphenyls	none	0.000001	0.000001	none
Selenium	0.01	***	***	none
Silver	0.05	***	***	none
Zinc	(aesthetic)	***	none	none

* Soft water is defined as having less than 100 mg/l hardness as $CaCO_3$. Hard water has 100 mg/l or more of $CaCO_3$.

** The recommended limit is 0.01 of a 96-hour LC_{50} value, using the receiving or comparable water as the diluent and soluble lead measurements (non-filtrable lead using a 0.45 micron filter) for sensitive freshwater fish species.

*** The recommended limit is 0.01 of the 96-hour LC_{50}, as determined by a bioassay of a sensitive resident fish species.

+ The recommended limit is 0.1 of the 96-hour LC_{50}, as determined by a bioassay of a sensitive aquatic resident species.

TABLE F - WATER QUALITY CRITERIA (continued)

Pesticides	Domestic Water Supplies (Micrograms/Liter)	Freshwater Aquatic Life (Micrograms/Liter)	Marine Aquatic Life (Micrograms/Liter)
Chlorinated Hydrocarbon Insecticides			
Aldrin - dieldrin*	none	0.01	0.004
Chlordane	0.2	0.01	0.01
DDT*	0.003	0.01	none
Endrin	0.01	0.01	0.1
Endosulfan	4.0	0.01	0.05
Heptachlor	100.0	0.02	0.03
Lindane	5.0	0.01	0.01
Methoxychlor			
Toxaphene			
Organophosphate Insecticides			
Demeton	none	0.1	0.1
Guthion	none	0.01	0.01
Malathion	none	0.1	0.1
Parathion	none	0.1	0.1
Chlorophenoxy Herbicides			
2, 4 - D	100.0	none	none
2, 4, 5 - TP	10.0	none	none
Organochloro Insecticide			
Mirex	none	0.001	0.001

* The persistence, bioaccumulation potential and carcinogenicity of these substances make avoidable human exposure or release into waterways unreasonably hazardous.

the water quality criteria. Also, allowance for the amount of toxicant contributed by other environmental factors (e.g., food, lead inhalation) was made when determining recommended concentrations of a given substance for each of the purposes mentioned above.

Sec. 307 (a) - Toxic Pollutant List. This section of the FWPCA mandates the Administrator to publish a list of toxic pollutants for which effluent standards will be promulgated. The criteria used for selection of the toxic pollutants were published in the Federal Register, Vol. 38., No. 173, Sept. 7, 1973. The proposed toxic pollutant effluent standards, Federal Register, Vol. 38, No. 247, Dec. 27, 1973, were recently invalidated in court. Consequently, the criteria used for selection of these pollutants are currently under revision.

The criteria published in the Federal Register are briefly discussed as an indication of what the revised criteria might be. One criterion was concerned with a pollutant's toxicological properties. Evidence that a pollutant could be "highly toxic" to aquatic or non-aquatic life was reviewed. The term "highly toxic to aquatic life" was defined as a substance having a 96-hour LC_{50} of 10 mg/l or less; this classification was taken from the National Academy of Sciences water pollution ranking system[1]. The term "LC_{50}" means that concentration of a substance in water which is lethal to one-half of the test population in the specified time period. The term "highly toxic to non-aquatic life" was defined as in Title 15, U.S. Code, Sec. 1261. Less standardized data, including data from sub-acute and chronic testing, were reviewed as well.

Toxicological data were reviewed for evidence of bioaccumulation through aquatic mechanisms to the extent of reproductive impairment or contamination of foods. Also, evidence of a substance having carcinogenic, mutagenic, or teratogenic properties and being stable in the aquatic environment was reviewed.

Another criterion was concerned with the seriousness of discharges or potential discharges from point sources. The production, distribution, and use pattern of the pollutant were determined. Identification of toxic pollutant discharges should demonstrate that substantial quantities of the pollutant, both in absolute terms and relative to non-point sources, have been deposited in the aquatic environment. Also, these discharges must have caused substantial environmental harm, as supported by documented damage to important organisms.

Sec. 311 (b)(2)(A) - Hazardous Substance Spills. This section of the FWPCA authorizes the Administrator to promulgate regulations designating as hazardous substances those elements and compounds which, when discharged in any quantity into or upon the navigable waters, adjoining shorelines or the waters of the contiguous zone, present an imminent and substantial danger to the public health or welfare. The constraint in designation of hazardous substances of an "imminent danger" precludes use of criteria characterized by long-term effects, i.e., bioaccumulation, carcinogenesis, mutagenesis, or teratogenesis. Consequently, hazardous substance designation is based on acute effects only.

Criteria to be used for hazardous substance designation under this section were proposed in the Federal Register, Vol, 39, No. 164, August 22, 1974, ("Designation and Removability of Hazardous Substances from Water"). The oral, dermal, and inhalation toxicity criteria are identical to the "highly toxic" criteria found in Title 15, U.S. Code, Sec. 1261. Also, substances having a median inhibitory limit (IIm) of 100 ppm or less are considered as having the potential for presenting an imminent and substantial danger to the environment when spilled. This criterion measures the decrease in aquatic flora, as indicated by a 50 percent decrease in cell count, biomass, or photosynthetic ability over a 14-day period. This criterion, while not specifically mentioned in Sec. 311, is included because aquatic plant life is of critical importance to aquatic fauna.

The last toxicological criterion used in designation of hazardous substances is a 96-hour aquatic LC_{50} of 500 ppm. The basis for the chosen limit is a calculation determining the achievable pollutant concentration in the average spill situation. Assumptions are made concerning the volume of water flowing in a stream, the size of a water body, uniform mixing within a given discharge time, and concentration of hazardous substances likely to result from typical capacity sizes of various transportation modes. The calculation then predicts that the concentration of a hazardous substance would rarely exceed 500 ppm.

Another criterion mandates that a reasonable potential for spillage of the material be established. Factors considered in making this evaluation

include the production quantities, modes of transportation, handling and storing practices, past spill experience, and physical-chemical properties of each substance.

Additionally, EPA is soliciting comments on the economic impact of the proposed regulation. The cost of spill prevention or the impact of penalties borne by affected parties will be considered.

Clean Air Act - Sec. 112

This section of the Clean Air Act authorizes the Administrator to publish a list of hazardous air pollutants for which emission standards will subsequently be promulgated. "Hazardous air pollutants" are those which may cause, or contribute to, an increase in mortality or an increase in serious irreversible or incapacitating reversible illness. This definition is concerned only with the safeguarding of human health.

A preferred standards path analysis is performed for a pollutant being considered for hazardous designation. Ambient air data, health effects information, the technical feasibility of controlling emissions, and the economic implications of regulating the substance are assembled in an analytic document. Considering all this information and anticipating the practicality of emission standards implementation, decision-makers subjectively pass judgment as to whether or not a substance should be designated as hazardous. Asbestos, beryllium, and mercury, having been designated as hazardous, are currently regulated by emission standards.

EPA Sewage Sludge Working Group

This Working Group is presently formulating guidelines for the heavy metal content of sewage sludge applied to cropland or land used for cattle grazing. Recommended levels have yet to be determined.

TRW Systems Group[5]
Recommended Methods, of Reduction, Neutralization, Recovery, or Disposal of Hazardous Waste

The TRW report initially classifies waste stream constituents into three categories: Category 1, candidates for National Disposal Sites; Category 2, candidates for Industrial Disposal; and Category 3, candidates for Municipal Disposal. Classification of waste stream constituents requires consideration of both the hazards associated with the constituents and the evaluation of the adequacy of the currently practiced treatment and disposal practices. The criteria used in classifying waste stream constituents are as follows:

> Category 1: Materials are very difficult to handle, have Threshold Limit Values less than or equal to 1 ppm, and/or are very highly flammable, and/or are currently regulated or considered for regulation by the Environmental Protection Agency.
>
> Category 2: Material can be handled by normal industrial procedures, can be incinerated with proper scrubbing equipment, buried without treatment in a Class 1 landfill, or broken down by biological processes as utilized by industry.
>
> Category 3: Materials are relatively easy to handle, can be incinerated without scrubbing, buried in a Class 2 landfill, or treated by municipal sewage treatment processes.

The landfill classifications are taken from the California State Department of Public Health, the Department of Water Resources. Class 1 landfills are those sites located over non-water bearing sediments or with only unusable ground water underlying them. The site location must provide complete protection from flooding, surface runoff or drainage, and waste materials and all internal drainage must be restricted to the site. Class 2 landfills are sites underlain by usable ground water, and they may be located adjacent to streams. A distance of separation must be maintained between the bottom of the fill and the water table. Surface water must be restricted from the site, to preclude water contact with the wastes.

A Profile Report is prepared for each of the waste stream constituents studied. The first three sections of the report present information characterizing the waste stream constituent. An introductory section contains such information as manufacturing techniques, production rates, use patterns, and types, quantities, sources, and distribution of wastes containing the constituent. Pertinent physical/chemical properties of the material are also summarized here. A toxicology section generally documents recommended Threshold Limit Values (TLV) for man, the TLm for fish, acute oral and dermal LD_{50} values for various forms of animal life, plant reactions following exposure, and exposure symptoms in man. (The TLV is that concentration of an airborne constituent to which workers may be exposed repeatedly, day after day, without adverse effect.) A section describing other than toxicological (or radiation) hazards completed the characterization of the constituent. The types of

hazards included in this section are flammability, explosiveness, corrosiveness, and detectability.

The next section of the Profile Report discusses the overall hazard associated with the waste management sequence between waste constituent generation and waste disposal. Adequate waste management is defined in terms of maximum acceptable levels of occurrence in air, water, and soil, based mainly but not solely on the toxicological effects of the waste constituent. Maximum acceptable levels of occurrence are designated as Recommended Provisional Limits.

The Recommended Provisional Limits in air are equal in value to one-hundredth of the established TLV. For constituents without an established TLV, that of a structurally related compound is used. The Recommended Provisional Limits in water and soil are equal in value, based on the worst case assumption that contaminated soil is completely non-retentive, and that the contaminant eventually percolates to the ground water table, and eventually becomes potable water. These concentration limits are equal in value to current drinking water standards, or one-hundredth of the lowest reported drinking water study level in cases where no drinking water standard exists.

In the absence of drinking water standards or study limit values, provisional limits are calculated on the basis of the Stokinger and Woodward method. By this method, limiting concentrations for water are based on the

TLV's of hazardous materials. The assumption underlying this method is that the noninjurious amount taken into the blood stream by inhalation is equal to that which can be taken orally in water. When this calculation is applied and no established TLV exists, then the TLV of a structurally related compound is used.

TRW reports that in a reasonable number of instances drinking water standards are roughly approximated by using a 100-fold safety factor to the lowest drinking water study levels or to the limits obtained by the Stokinger and Woodward method. Limiting concentrations for organic compounds present the greatest difficulty, however. The Stokinger and Woodward limits often exceed the minimum concentration producing detrimental effects in fish. Also, the calculated value may greatly exceed known odor and taste thresholds for man. In the absence of additional toxicity or annoyance data, a 100-fold safety factor is applied to the calculated values to give the provisional limiting concentrations.

As an additional safety feature, these limiting concentrations are compared with "safe" concentrations for fish. The rule-of-thumb method for determining the "safe" concentration, as reported by Sprague, is to multiply the 48-hour TLm by one-tenth. Generally, recommendations for maximum levels are 0.1 to 0.05 toxic units for non-persistent pollutants, and 0.1 to 0.01 toxic units for persistent chemicals and pesticides, mostly of the lower figure. In the absence of TLV's for man, fish limits serve as tentative limiting concentrations for man.

TABLE G

CRITERIA FOR THE IDENTIFICATION OF CANDIDATES FOR
NATIONAL DISPOSAL SITES

QUANTITY CRITERION

(1) Material is present in sizable quantities as a waste.

HAZARD CRITERIA

(1) Waste material is highly toxic.

(2) Waste material is toxic and not degraded, oxidized, reduced or combined to a nontoxic form by air, water, or soil organisms.

(3) Waste material is radioactive with long half-life and/or high level radiation.

(4) Waste material is spontaneously combustible or is an explosive sensitive to heat or mild shock.

TREATMENT CRITERIA

(1) No disposal method other than long term or permanent storage is considered adequate for the material.

(2) Adequate disposal techniques for the material are too specialized or complex for general application.

(3) Adequate disposal methods for the material are under development but not yet available, requiring short term storage.

The ratio of the five-day biological oxygen demand to the ultimate oxygen demand is used as a measure of persistence of a substance in the environment. Any substance with a value less than 20 percent is considered to be persistent. Available data on the accumulation of toxic substances in the ecologic cycle is also used in evaluating the persistence of a substance.

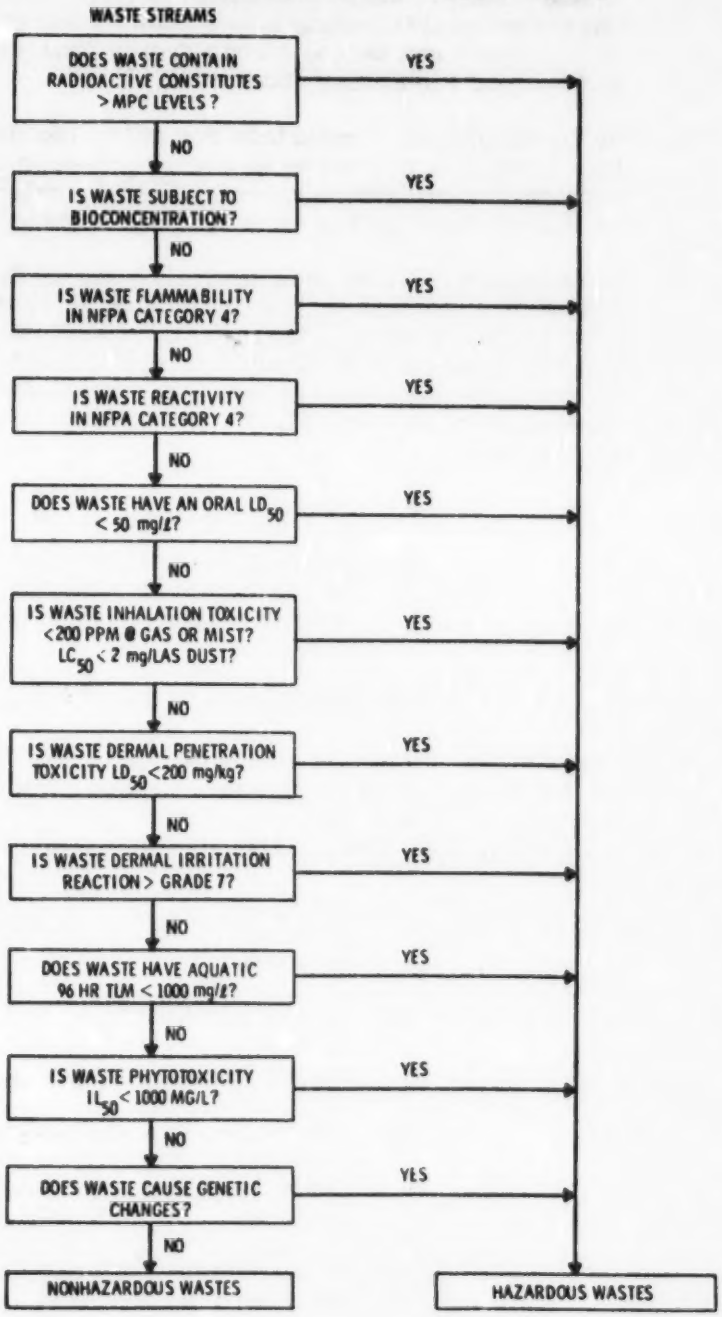
The last two sections of the Profile Report are concerned with evaluation of current waste management practices and applicability to the concept of National Disposal Sites. Current waste management practices are evaluated in regards to disposal efficiency, operational safety, and environmental impact. The final section recommends the general class of waste treatment required by the subject waste stream constituents. The criteria used for the identification of candidates for National Disposal Sites are listed in Table G[5] . This set of criteria reflects: (1) the abundance of the material present as wastes; (2) the degree of hazard associated with the waste material, and (3) the complexity of treatment that is required in the disposal/recovery of the waste material. Unfortunately, the criteria do not define "sizable quantities," "highly toxic," or "toxic."

Battelle Memorial Institute[6]
Program for the Management of Hazardous Wastes

Battelle utilized a decision model (Figure 1) in determining which waste streams should be designated as hazardous[6]. All waste streams were candidates for hazardous waste designation, regardless of production quantities.

FIGURE 1

GRAPHIC REPRESENTATION OF THE HAZARDOUS WASTE DECISION MODEL



A waste stream meeting any of the following criteria was designated as hazardous:

1. Radioactivity: waste streams containing radioisotopes above the accepted maximum permissible concentration (MPC) levels set by the Atomic Energy Commission (now the Nuclear Regulatory Commission).

2. Bioconcentration: materials for which the detoxification-excretion mechanism is either non-existent or extremely slow, (these materials can be categorized as either heavy metals or persistent organic materials).

3. Flammability: waste streams qualifying as Category 4 flammable materials by the National Fire Protection Association (NFPA No. 704M). The classification is roughly equivalent to Grade 4 of the National Academy of Sciences (NAS) fire hazard scale mentioned earlier. Generally, materials qualify as Category 4 flammable if they are:

    (a) flammable gases;

    (b) flammable liquids with boiling points or flash points below 100 F and vapor densities greater than or equal to 1.1, or

    (c) spontaneously combustible in air.

4. Reactivity: materials which in themselves are capable of detonation or of explosive decomposition or explosive reaction at normal temperatures and pressures, Category 4 of NFPA, (No. 704M). The major areas of concern include:

    (a) Detonation by electrical shock; pertinent data can be found in the National Electric Code, (NFPA No. 70);

    (b) Oxidizing materials, includes Grade 4 self-reactive materials in the NAS rating system;

    (c) Polymerization; hazardous wastes capable of auto-polymerization, includes Grade 3, self-reactive agents in NAS ratings;

    (d) Explosiveness; primary high explosives rated at five inches or less on the

Picatinny Arsenal scale, and

(e) Water or air reactive wastes; includes material rated as Grade 4 water reactive in the NAS rating system.

5. Oral Toxicity: waste streams having an oral LD_{50} to man or rats less than or equal to 50 mg/kg. Test data for species other than humans or rats, or by routes of administration other than oral are used to estimate an oral value for man or rats in the absence of such data.

6. Inhalation toxicity: waste having an inhalation LC_{50} of 200 ppm or less as a vapor or 2 mg/l or less as a dust or mist.

7. Dermal penetration: wastes having a dermal LD_{50} of 50 mg/kg or less.

8. Dermal irritation: wastes scoring eight or better on the FDA skin irriation scale (Title 21, CFR, Sec. 191.11), or a rating of eight or better on the 10-grade scale devised by Smyth, et al. A grade eight rating on the latter scale represents severe irritant effects after a dilution of 100 to 1.

9. Aquatic toxicity: wastes displaying a 96-hour TLm of 1,000 ppm or less. This level was based on thresholds then being proposed by EPA pursuant to Sec. 311 of the FWPCA. The proposed threshold for aquatic life was subsequently revised to a 96-hour TLm of 500 ppm, (Federal Register, Vol. 39, No. 164, August 22, 1974).

10. Phytotoxicity: wastes having a mean inhibitory limit, (TLm) of 1,000 ppm or less. This level was chosen for reasons similar to those for selection of the aquatic toxicity threshold. Also, the proposed threshold for aquatic flora was subsequently revised to an TLm of 100 ppm, (see previous reference).

11. Genetic effects: wastes found to give positive results to standard genetic tests. Standard tests for determining carcinogenic, mutagenic, or teratogenic potential have been developed by the National Cancer Institute.

The decision model just outlined is designed to evaluate entire waste streams. Unfortunately, a paucity of waste stream data has been collected to date. Lacking such data, many classification systems rely on the pure compound approach, successive testing of each waste stream constituent, for determining whether or not a waste stream should be designated as hazardous. Battelle employs a variant of this approach for classifying waste streams. An assumption is made that all

constituents are additive in their effects. The additive estimation of toxicity levels for waste streams is calculated by use of the following model:

$$1/Y \text{ waste} = \sum_{x=1}^{a} Px/Yx$$

where "Y" is the toxicity measurement, i.e., TLm, IIm, oral or dermal LD_{50} or inhalation LC_{50} , and "Px" is the fraction of constituent "x" in the waste stream.

Clearly, toxicological data are not always additive. Smyth, et al., found that oral LD_{50} values for combined organic solvents were quite close to predicted values. For materials with distinctly different toxic effects, the estimated limit serves as a maximum unless synergism comes into play.

For other than toxicological measurments, the additive estimate is not as neatly calculated for the waste stream. Greater subjective judgment for estimating an entire waste stream's flammability, reactivity, or dermal irritation ratings is required. Evaluation of a waste stream's potential for bioconcentration and genetic activity is quite difficult, making the additive estimations techniques highly judgmental.

Booz-Allen Applied Research, Inc.[7]
A Study of Hazardous Waste Materials, Hazardous Effects and Disposal Methods

This report evaluated the degree of hazard associated with a substance in terms of its potential effect on human health and welfare and on other ecological populations. The human health and welfare category includes effects from flame,

explosion, or reaction, as well as toxic effects resulting from exposure to a given substance. The category involving other ecological populations documents the toxic effects resulting from plant or animal exposure to a given substance. The degree of hazard for each disposal or release medium (air, water, and soil) is evaluated in terms of the potential effects just described. The matrix of factors used for rating the level of effects for potentially hazardous substances is depicted in the following table:

Medium for Disposal	Hazard in Terms of Potential Effects		
	Human Populations		Eco Populations
	Toxic Effects (Th)	Flame/Explosion/ Reaction (Fh)	Toxic Effects (Te)
Air (A)	ATh	AFh	ATe
Water (W)	WTh	WFh	WTe
Soil (s)	STh	SFh	STe

Each element of the above matrix is rated using the following scale:

3-Severely hazardous

2-Slight to moderate hazard

1-Minimal hazard

U-Effects unknown

The acute exposure criteria used in designating a substance as severely hazardous for each of the nine elements depicted in the previous table were as follows: (Chronic exposure criteria, arbitrarily assumed to be 1/20 to 1/100 of acute exposures, were also used in designating a substance as severely hazardous.)

ATh: inhalation $LC_{50} \leq 5{,}000$ mg/m3; or TLV ≤ 500 mg/m3

WTh: oral $LD_{50} \leq 50$ mg/kg; or TLV ≤ 5 mg/kg

STh: severely hazardous percutaneously on direct contact

AFh: $F_p \leq 100°F$ and $B_p \leq 100°F$; spontaneous combustion and/or explosive reaction

WFh: reacts explosively with water without requiring heat or confinement

SFh: readily capable of detonation and explosive decomposition or reaction at normal ambient temperatures and pressures

ATe: inhalation $LC_{50} \leq 2000$ mg/m3, or TLV ≤ 200 mg/m3

WTe: $TL_m \leq 100$ mg/l; or TLV ≤ 10 mg/l

STe: highly lethal on contact to most vegetation and/or earth organisms.

NOTE: No time limit for any toxicity measurement, LC_{50}, LD_{50} or TL), was given. Also, the definition of TLV was expanded to include that dose (mg/kg body weight) to which humans or animals may be exposed repeatedly or continuously day after day without suffering adverse effects.

Once ratings for a particular susbtance have been developed for each element in the potential effects matrix, they are summed vertically and horizontally to give a total effects rating. Production and distribution rating criteria are then factored into the calculation according to the following scales:

Production Rating Criteria

1.5 - Large production, amounts exceeding 10^8 pounds (50,000 short tons), annually

1.25 - Moderate production, amounts at least 10^7 pounds (5,000 short tons), but less than 10^8 pounds annually

1.0 - Low production, amounts less than 10^7 pounds

U - Unknown

Distribution Rating Criteria

0.5 - Wide distribution, more than 10 major producers, shipments in less than tank car containers, used as both intermediate industrial and consumer product.

0.25 - Moderate distribution, 5-10 major producers, large shipments

0.0 - limited distribution, less than 5 major producers.

The final hazard rating is derived by multiplying the sum of the production and distribution ratings by the total effects rating. Additionally, a maximum potential hazard rating is calculated by assigning a maximum hazard value of three for each unknown and incorporating this factor into the total effects rating.

DEPARTMENT OF DEFENSE

Department of the Army, Materiel Command, Edgewood Arsenal

A ranked list of industrially supplied chemicals by acute toxicity, (mammalian oral consumption), is maintained by the Department of the Army, Materiel Command, Edgewood Arsenal. The oral LD_{50} of each chemical is classified on a scale ranging from an insignificant toxicity category, to progressively more toxic categories. The classification used at this facility is as follows:

	Classification	Oral LD_{50} (mg/kg)
0	Insignificant toxicity	above 5,000
1	"	500-5,000
2	"	50-500
3	"	5-50
4	Most Toxic	5

Department of the Navy[8]
Consolidated Hazardous Item List

The potential danger of supply materials is evaluated in regards to health hazard, flammability, reactivity, corrosivity, oxidation capacity, radioactivity, magnetic properties, or fire-fighting hazard. The degree of hazard classifications relative to health, flammability, and reactivity are those contained in NFPA Protection Guide No. 704M. This system utilizes five hazard levels, from four (4), indicating a severe hazard, to zero (0), indicating no special hazard. The degrees of hazard relative to flammability

are outlined in this publication as follows:

Hazard Level	Criteria
4	$Fp < 73^{\circ}F$ and $Bp < 100^{\circ}F$
3	$Fp < 73^{\circ}F$ and $Bp > 100^{\circ}F$, or $73^{\circ}F < Fp < 100^{\circ}F$
2	$100^{\circ}F < Fp < 200^{\circ}F$
1	$Fp > 200^{\circ}F$
0	Material will not burn.

STATE REGULATIONS

California State List

The State of California classifies waste as hazardous if it satisfies the criteria for any of the following categories: (1) toxic, (2) corrosive and irritant, (3) flammable, (4) explosive, or (5) strong sensitizer.[9]

The toxic category is subdivided into "highly toxic" and "toxic" classifications. The "highly toxic" subcategory is identical to that defined in Title 15, U.S. Code, Sec. 1261. The "toxic" subcategory includes those substances having (i) an oral LD_{50} greater than 50 mg/kg but not more than 500 mg/kg, (ii) an inhalation LC_{50} greater than 2 mg/l but not more than 5 mg/l, or (iii) a dermal LD_{50} greater than 200 mg/kg but less than 2,000 mg/kg.

The terms "corrosive," "irritant," "flammable," and "strong sensitizer" are defined as in Table 15, U.S. Code, Sec. 1261, with the exception that a "combustible" classification is not included as part of the flammable category.

An explosive is defined as in Title 49 (Transportation), CFR, Sec. 173.50.

REFERENCES

1. System for evaluation of the hazards of bulk water transportation of industrial chemicals; a report to the Department of Transportation, United States Coast Guard. Washington, National Academy of Sciences--National Research Council, Feb. 1974. 42 p. (Distributed by National Technical Information Service, Springfield, Va., as AD-782 476.)

2. Christensen, H. E., T. T. Luginbyhl, B. S. Carrol. The toxic substances list; 1974 edition. HEW Publication No. (NIOSH) 74-134. Rockville, Md., U.S. Department of Health, Education, and Welfare, June 1974. 904 p.

3. Personal communication. H. E. Stokinger, National Institute for Occupational Safety and Health, to A. M. Kohan, Office of Solid Waste Management Programs, Dec. 1974.

4. Flinn, J. E., T. J. Thomas and M. D. Bishop. Literature search and state-of-the-art study of identification systems for selecting chemicals or chemical classes as candidates for evaluation; final report. Washington, U.S. Environmental Protection Agency, [1974]. 60 p.

5. Ottinger, R. S., et al. [TRW Systems Group.] Recommended methods of reduction, neutralization, recovery or disposal of hazardous waste. U.S. Environmental Protection Agency, Aug. 1973. 16 v. (Distributed by National Technical Information Service, Springfield, Va., as PB-224 579.)

6. Program for the management of hazardous wastes for Environmental Protection Agency, Office of Solid Waste Management Programs; final report. Richland, Wash., Battelle Memorial Institute, July 1973. 385 p.

7. Booz Allen Applied Research, Inc. A study of hazardous waste materials, hazardous effects and disposal methods. U.S. Environmental Protection Agency, 1973. 3 v. (Distributed by National Technical Information Service, Springfield, Va., as PB-221 464.)

8. Consolidated hazardous item list; storage and handling. NAVSUP Publication 4500. Mechanicsburg, Pa., Department of the Navy, Navy Fleet Material Support Office, 1 July 1972.

9. Listing of extremely hazardous waste, Sec. 25115, Health and Safety Code of California. State of California Statues of 1972. v.1. p. 2387-2393.

DEC 1974

NIOSH Recommended Standards Developed Under the Occupational Safety and Health Act

Ammonia	July 15, 1974
Arsenic	January 21, 1974
Asbestos	January 21, 1972
Benzene	July 24, 1974
Beryllium	June 30, 1972
Carbon Monoxide	August 3, 1972
Chloroform	September 11, 1974
Chromic Acid	July 17, 1973
Coke Oven Emissions	February 28, 1973
Cotton Dust	September 26, 1974
Hot Environments	June 30, 1972
Inorganic Lead	January 5, 1973
Inorganic Mercury	August 13, 1973
Noise	August 10, 1972
Silica	November 11, 1974
Sulfuric Acid	June 6, 1974
Sulfur Dioxide	February 11, 1974
Toluene	July 23, 1973
Toluene Diisocyanate	July 13, 1973
Trichloroethylene	July 23, 1973
Ultraviolet Radiation	December 20, 1972
Vinyl Chloride	March 11, 1974

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Carbon Tetrachloride
Dioxane
Egress from High Structures
Fluorides
Hexavelent Chromium Compounds
Hydrogen Cyanide
Methylene Chloride
Nitric Acid
Oxides of Nitrogen
Parathion
Sodium Hydroxide
Xylene
Zinc Chloride
Zinc Oxide
Labelling

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Acetylene
Carbaryl
Chlorine
Ethylene Dichloride
Fibrous Glass
Fluorine
Formaldehyde
Hydrogen Fluoride
Isopropyl Alcohol
Malathion
Methyl Alcohol
Methyl Parathion
Phenol
Phosgene
Phosphine
Phosphoric Acid
Phosphorus
Sodium Cyanide
Tetrachloroethylene
1,1,1-Trichloroethane

FY 77

Carbon Dioxide

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